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REPORT SE-92-01

INDUSTRIAL POWER SPRAY WASHER

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Rock Island Arsenal
Rock Island, Illinois 61299-5000

19 September 1991

Technical report for MMT Project 6XX8250,
"Improved Fabrication of Recoil Components"

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The method of cleaning M178 recoil components prior to final assembly has varied over the past 25 years. Introduction of new cleaning methods and chemicals over this period has caused a small improvement on how well these components were cleaned. Therefore, a more effective method for cleaning the components needed to be developed. An aqueous power spray washer was designed to clean all M178 gun mount components, except for the M178 cradle assembly. Benefits realized from this unit include better cleaning, greater productivity, absence of a hand washing operation and elimination in the use of hazardous solvents.

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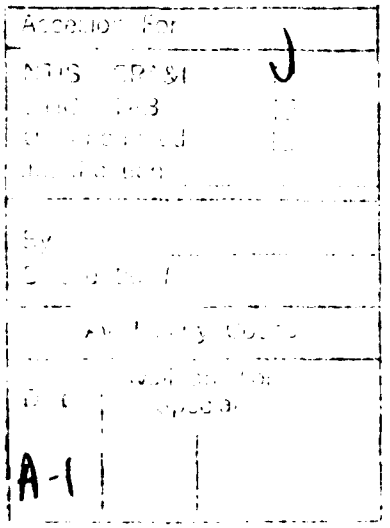
PREFACE

The work described in this report was supported by the U.S. Army's Manufacturing Methods and Technology program. This effort was performed as part of Manufacturing Methods and Technology project 6XX8250, Improved Fabrication of Recoil Components, which addressed both machining and cleaning issues in the manufacture of recoil components. The scope of this effort was to find an alternative method of cleaning M178 recoil components prior to final assembly.



ACKNOWLEDGEMENTS

The author wishes to thank Dr. Richard Kalkan of the Rock Island Arsenal for his input and many constructive comments in writing specifications for the power spray washer. In addition, special thanks is given to Rock Island Arsenal recoil assembly personnel for their assistance in conducting acceptance testing of the power spray washer.

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1.0 INTRODUCTION

Recoil mechanisms have components in very close proximity which slide past each other at high velocities. Consequently, particulate contamination of the hydraulic oil in the recoil assembly is tested. Historically, M178 recoil assemblies have to be frequently retested due to particulate contamination of the hydraulic recoil oil. Therefore, control of cleanliness, especially over particulate contamination, of the M178 recoil components prior to final assembly has especially been a major concern. In this project, an industrial power spray washer was conceived, built and tested to clean the M178 components. Critical M178 components include the outer orifice, inner orifice, piston tube recuperator cylinder, buffer cylinder and followers (Appendix A). The most common type of contaminants found on M178 recoil components are metal chips (ferrous and nonferrous), light oils, honing oils and abrasive material (honing stone material).

Before implementation of the power spray washer, three basic cleaning methods were used in cleaning large M178 recoil components. Between 1968 and 1975, the first method used in cleaning recoil components consisted of vapor degreasing and dip tank cleaning, both using 1,1,1 trichloroethane (TCEA). Because of the health hazards associated with TCEA, the TCEA dip tanks were discontinued in the late 1970s. During this time, the second cleaning method was ultrasonics with mild alkaline detergent and vapor degreasers with TCEA. By 1985, the third cleaning method evolved using vapor degreasing with TCEA, ultrasonics with alkaline detergent, hand scrubbing and rinsing. This third method introduced a solvent made from natural oranges (d-limonene), which was used in the final hand scrubbing operation. Trade names of this orange-based solvent included Safe-T-Solv and F-101. F-101 emulsified better in water and was the last alkaline detergent to be used in the dip tank operation. The rinse solution in this method consisted of a rust inhibitor, trade name Detrix-4275, at 5 percent concentration. Both wash and rinse solutions were filtered through 5 micron polypropylene bags and heated to 130 degrees F.

Although three different basic cleaning methods had been used for large parts, small dip tanks with TCEA had been continuously used for smaller parts. In all instances, TCEA had been used and created health concerns among the workers. The research in finding an effective parts washer in cleaning M178 recoil components started in August 1987.

The primary purpose in acquiring a power spray washer was to provide better and more effective cleaning of the M178 recoil components. Therefore, objectives were to reduce retesting and rebuild, while increasing productivity.

2.0 PARTICULATE CONTAMINATION CRITERIA FOR RECOIL COMPONENTS IN A HYDRAULIC FLUID WITHIN RECOIL ASSEMBLIES

No particulate contamination criteria have ever been required for individual M178 recoil components prior to final assembly. However, level 300 cleanliness in MIL-STD-1246B does provide a basis and a uniform method for specifying product cleanliness levels and contamination control program requirements (Appendix B). The last level 300 test conducted on M178 recoil components was in February 1984.

After an M178 gun mount is built, it is gymnasticated (exercised) at various elevations. Within 5 minutes of gymnastication, a 16-ounce hydraulic oil sample is taken from each of the upper and lower recoil cylinders. Every hydraulic oil sample taken is called a rework. The hydraulic oil is filtered gravimetrically through a Whatman number 4 cotton filter. The particles are counted manually with an optical microscope between 20x and 70x magnification. The five types of particles counted include ferrous, nonferrous, abrasive, nonabrasive and lint and fiber. Although there is no cleanliness requirement on the individual components, each upper and lower cylinder assembly of every M178 gun mount must pass stringent contamination criteria (Appendix C). This criteria was established when the initial M178 gun mounts were built at Rock Island Arsenal during the late 1960s. If the hydraulic oil samples fail to meet this contamination criteria after three consecutive oil samples (reworks), the gun mount is sent back to recoil assembly, torn down, rebuilt and retested. To date, the average number of reworks for an M178 gun mount is approximately 2.5 reworks.

3.0 ADVANTAGES OF THE POWER SPRAY WASHER

There are many advantages in using a power spray washer for cleaning M178 recoil components. The first and foremost advantage in using a power spray washer is that it removes particulates and light oils better, as it provides impingement of water to all surfaces of components.

The separate wash and rinse cycle provides exceptional rinsing of parts also. The deionized water, makeup water and in-line filters used for the recycled wash and rinse solutions provide the highest quality water for this type of parts cleaning.

The automated operation of the power spray washer requires minimum operator intervention, so the operator can perform other tasks. The only operator intervention during the entire cleaning process is the loading and unloading of components in and out of the washer. A ceiling-mounted hydraulic hoist can be used for the heaviest components, as when open, the door provides overhead and side accessibility to at least half the turntable width. The parts are held accurately and firmly enough by the fixtures to make sure that even the 1/4-inch base of the inner orifice is washed; yet, loading and unloading can be accomplished in 10 minutes total.

There are no hazardous wastes produced by this type of parts washer. The washer uses an alkaline, sodium metasilicate-based detergent, trade name "Natural Orange", made by Better Engineering. It has a wash tank of 150-gallon capacity and a rinse tank of 150-gallon capacity, and when the filtering of these solutions becomes insufficient, the solutions can be disposed by dumping down the sanitary sewer. The rinse water temperature can be from 120 to 170 degrees F., which enables flash drying of the parts. It takes approximately 10 minutes to wash, rinse and flash dry <u>eight</u> components compared to 10 minutes for <u>each</u> component using the vapor degreasing, ultrasonic, hand scrubbing and rinsing sequence. In addition, there are no significant safety hazards associated with this type of cleaning operation. The process takes place in an enclosed cabinet, and the most likely safety concerns are the operator dropping a part or touching a still hot part.

4.0 DESIGN CONCEPT OF THE CUSTOM POWER SPRAY WASHER

Based upon a commercial model of a power spray washer, this washer was designed specifically to clean M178 recoil cylinders (Figures 1-2). Five major features were considered in designing the power spray washer. They are as follows: 1) the ability of all surfaces of the components to be impinged by the cleaning solution; 2) high quality water for wash and rinse solutions; 3) separate wash and rinse cycles; 4) fully automated operation; and 5) large loading capacity.

Each of the five components fits in a particular place in the fixturing, which locates the center of the part relative to the center of the turntable on which it sits. The spray orifices in the power spray washer have been designed specifically to impinge wash and rinse solutions to all the surfaces of all components. The orifices have been positioned individually above and below the parts specifically to match the part passing by when the turntable rotates. In addition, there are spray orifices directed to the parts from the side.

A cartridge style deionizer unit was added in-line to provide high quality makeup water for the wash and rinse cycles and to assure good chemical mixing and a residue-free rinse.

The separation of wash and rinse cycles, each using separate tanks, allows for a higher concentration of alkaline detergent, which provides for better cleaning. The use of in-line filters enables the rinsing of all cleaning detergent. Separate rinsing temperature control and the addition of a rust inhibitor is needed, as rust cannot be tolerated.

The automated system was designed for minimal operator intervention, as the wash and rinse cycle times and solution temperatures are all preset by the operator. Besides loading/unloading components in and out of the washer, there is no operator intervention once the wash cycle begins. The parts washer can clean two complete sets of recoil components during a single wash/rinse cycle.

Other special design features include the ability to flash dry the parts, construction with corrosion resistant materials, and ease of disposal of spent solution. The ability of flash drying of components can be achieved when the rinse solution temperature is maintained at 150 degrees F. Flash drying can only occur if the components are exposed to ambient air immediately after the rinse cycle. The stainless steel construction provides cleaner wash and rinse solutions, as there is an absence of rust on the interior of the cabinet, which would flake off.

The basic design requirements and cleaning operation requirements of the power spray washer are shown in sections 4.1-4.12 and 4.2-4.2.8, respectively, of Appendix D.

5.0 FIRST ARTICLE AND ACCEPTANCE TESTING OF THE POWER SPRAY WASHER

First article tests were performed on a 200 DX model washer, and acceptance tests were performed on the final custom design washer. The purpose of the first article test was to demonstrate if the off-the-shelf

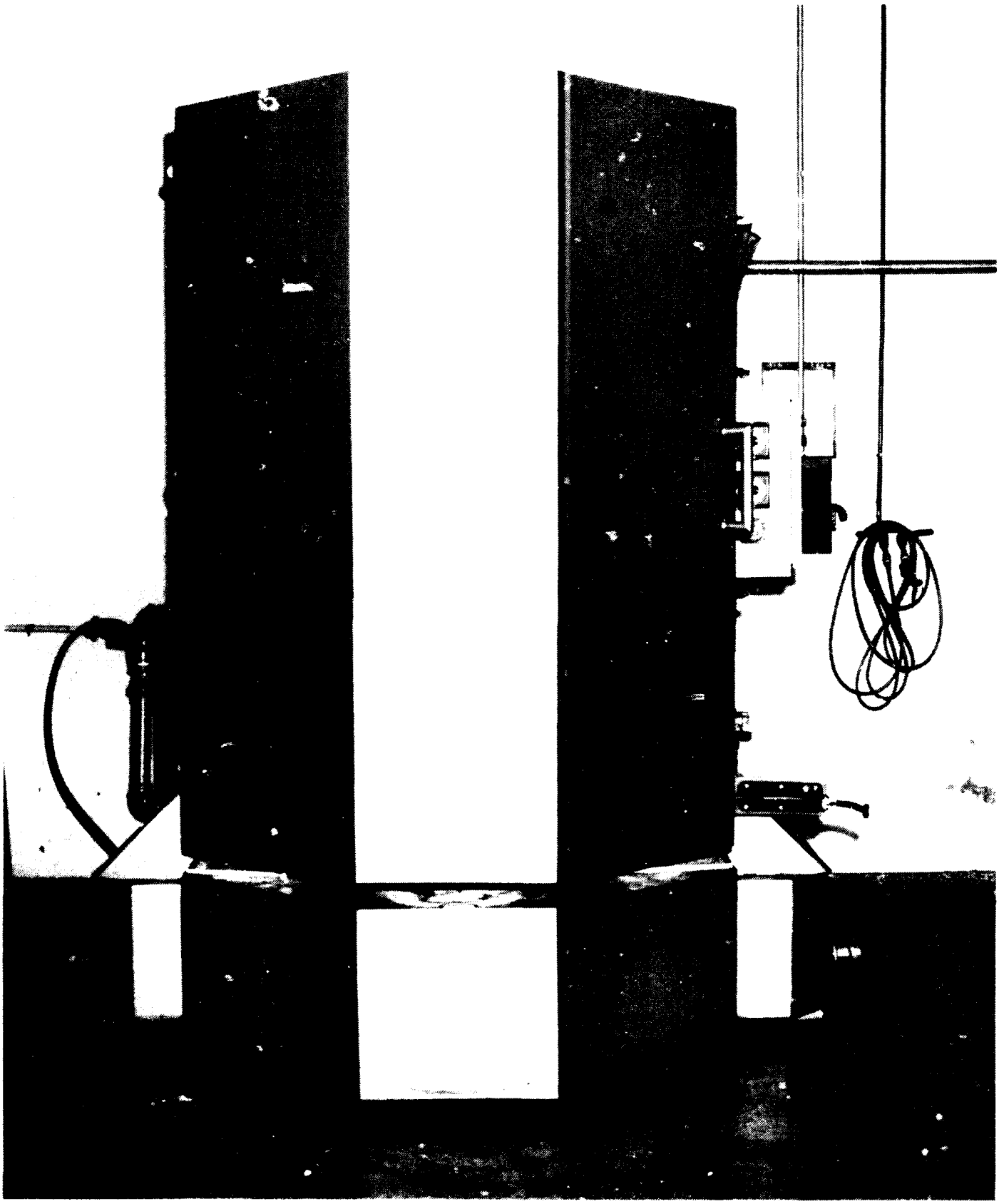

FIGURE 1
FRONT VIEW OF POWER SPRAY WASHER

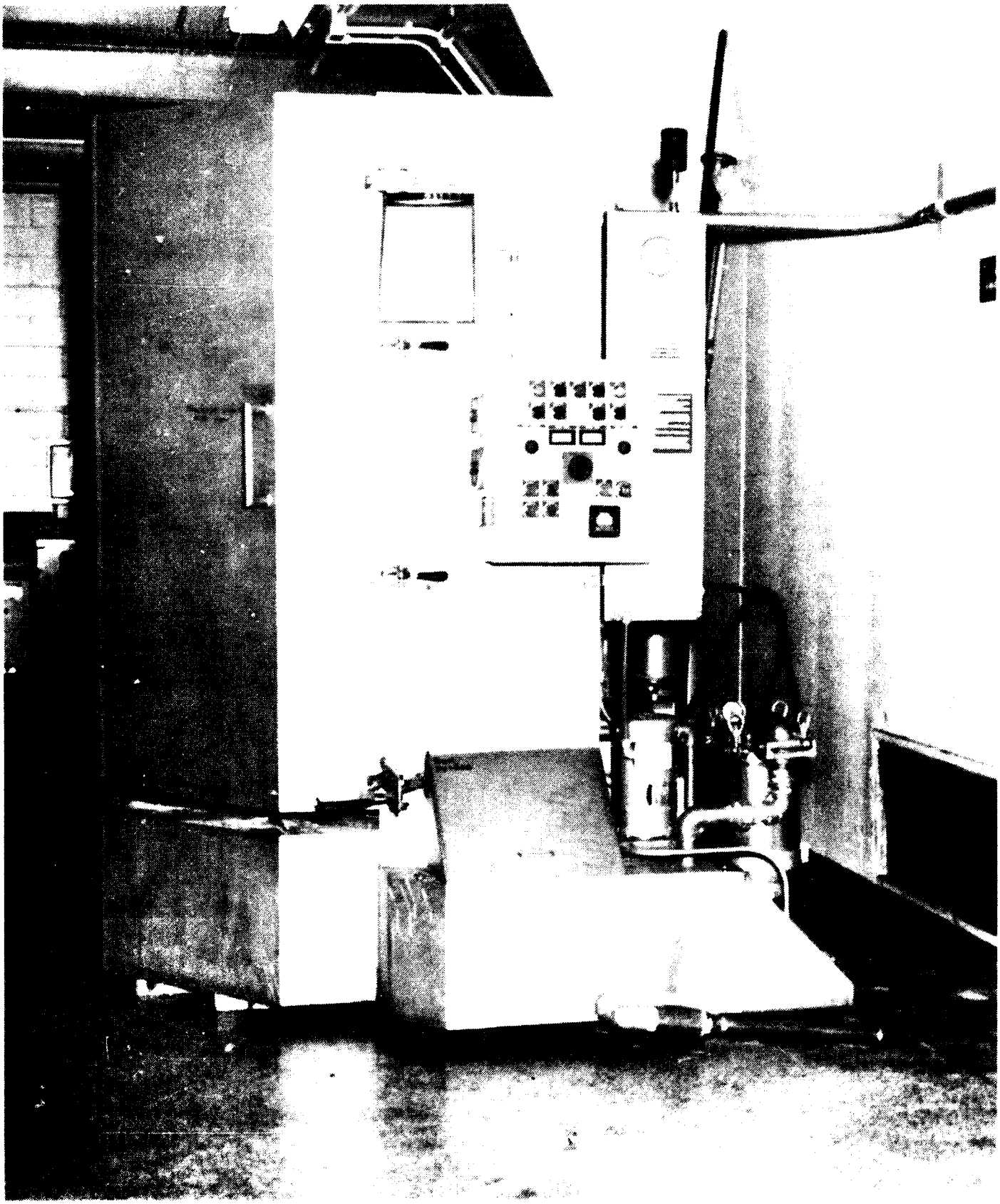

FIGURE 2
SIDE VIEW OF POWER SPRAY WASHER

washer could provide satisfactory cleaning of the M178 recoil components. The contractor, R.J. Bowers, Rockford, IL, and the fabricator, Better Engineering, Baltimore, MD, had no experience with the level 300 criteria specified for acceptance tests nor with the M178 recoil components, which have complex configurations. Better Engineering had to consider the complexity of the parts in designing the fixtures and the washer. Complex parts included the inner orifice with razor sharp flanges and 1/4-inch diameter hole throughout the length of the part, and the blind end of the piston tube. Therefore, they wanted to prove feasibility on essentially an off-the-shelf washer before constructing the custom washer.

For the first article test, seven pieces each of the recoil components were tested for level 300 cleanliness, with an exception to the recuperator cylinder where five components were used. The components were washed for 15 minutes in the power spray washer. All components were then immediately removed from the washer and rinsed with 16 ounces of 5-micron filtered water using a polypropylene spray bottle. This rinse water was collected for each cleaned component, and the rinse water sample was then filtered for microscopic analysis. The microscopic analysis method, in conducting the level 300 test, was the same as that noted in Section 2.0.

Twenty-three of the thirty-three components (70 percent) passed the level 300 test (Appendix E). Nonabrasives, lint and fiber particles were not taken into account in conducting the first article test, since this washer did not have a rinse cycle, and an M178 recoil assembly had not been failed for not meeting the lint and fiber criteria in 10 years. The requirement was a 70 percent passing rate. The contractor was informed in January 1990 that the first article test had been passed. As the first article washer did not have the ability to rinse the parts with hot water, rust on the first article test components was observed under close inspection. This confirmed the decision to have a rinse cycle with Detrix CP4275 rust inhibitor in water at 150 degrees F. capable of flash drying.

The final acceptance cleanliness test per paragraph 4.5.1 of the contract was modified. This change was made in conjunction with modification to the cleaning operation requirements of the specification. Initially, the contract had stated that the turntable holding the cylinder was to stop during interwash and interrinse cycles. Because of the specification of a friction drive for the turntable and the need to index precisely over the 1/4-inch bore of the inner orifice, this requirement could not be met. Instead, the turntable was designed to rotate continuously through the wash and rinse cycle at 3 rpm. As a result of this modification, which would reduce the period a spray was directed at a component, the final acceptance test passing requirement was increased from 70 percent to 90 percent to provide assurance that the power spray washer would still clean parts effectively.

The final acceptance test of the final custom design washer was conducted per contract, paragraph 4.5 (Appendix D). Thirty-two components were tested. Nearly 90 percent (28) of the components met the level 300 cleanliness test (Appendix F). Again, lint and fiber particulates were not part of the level 300 acceptance test.

6.0 PERFORMANCE OF THE POWER SPRAY WASHER

The power spray washer was put into use in May 1991. Between May 2 and June 29, 45 M178 recoil assemblies were cleaned by the power spray washer. The average number of reworks (oil samples) to pass the contamination criteria for these recoil assemblies was 2.30. In the three preceding months, the number of reworks to pass the M178 recoil assembly (using the previous cleaning method) was 2.5. The lower number of reworks for those mounts built between May 2 and June 29 can be attributed to cleaner components. Lower number of reworks results in significant cost savings in labor for gymnastication of the gun mount and for analysis of the particulates in the oil analysis. An M178 recoil mechanism has to be disassembled after three reworks and its components cleaned and reassembled. Therefore, the improvement in the average number of reworks translates into a significant productivity improvement for the highly trained, highly skilled recoil assembly operators.

The M178 gun mount has two recoil assemblies; the power spray washer (Figure 3) has cleaned nearly two complete sets (for two assemblies) of recoil components (12 parts total) in the same amount of time it takes to clean just three components using the hand washing operation.

The spent wash and rinse solutions present no waste disposal problems. The spent solutions have been disposed of via sewer to the city of Rock Island, Illinois. The maximum permissible concentration of fats, oils and greases (FOG) that can be discharged via sewer to the city of Rock Island is 100 parts per million. A weekly FOG analysis is conducted on the wash solution to ensure FOG concentrations do not exceed 100 parts per million, prior to discharge.

7.0 SUMMARY

The method in cleaning M178 recoil components has varied over the past 25 years. A more effective and efficient method for final cleaning of M178 recoil components had to be developed. The acquisition of the power spray washer has shown that the washer provides better cleaning compared to previous cleaning methods. A smaller average of M178 gun mounts requiring rework, large loading capacity of the washer and no waste disposal costs are major benefits derived from the implementation of this cleaning method.

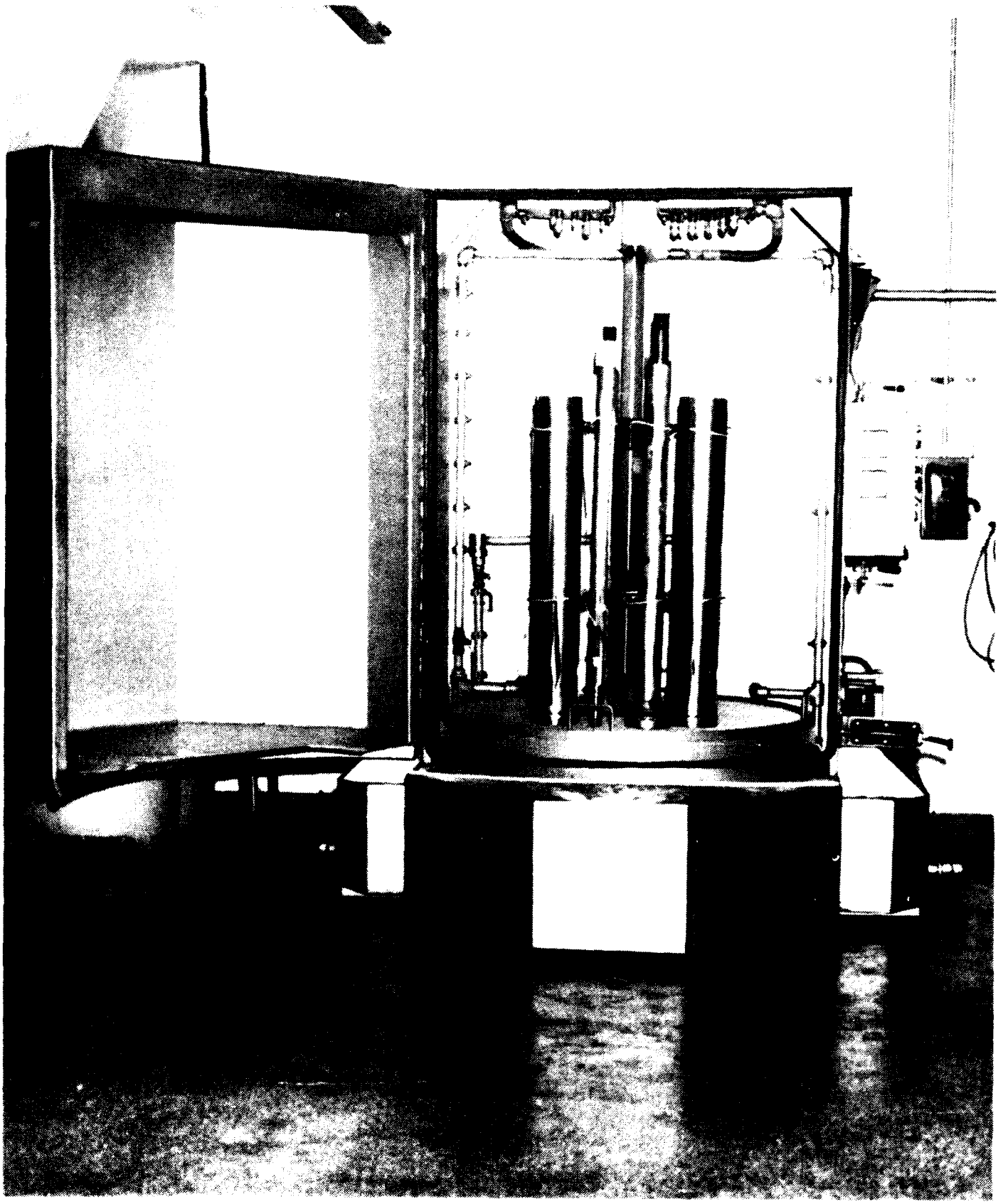

FIGURE 3
TYPICAL LOADING CAPACITY OF POWER SPRAY WASHER

APPENDIX A

DRAWINGS OF M178 RECOIL COMPONENTS

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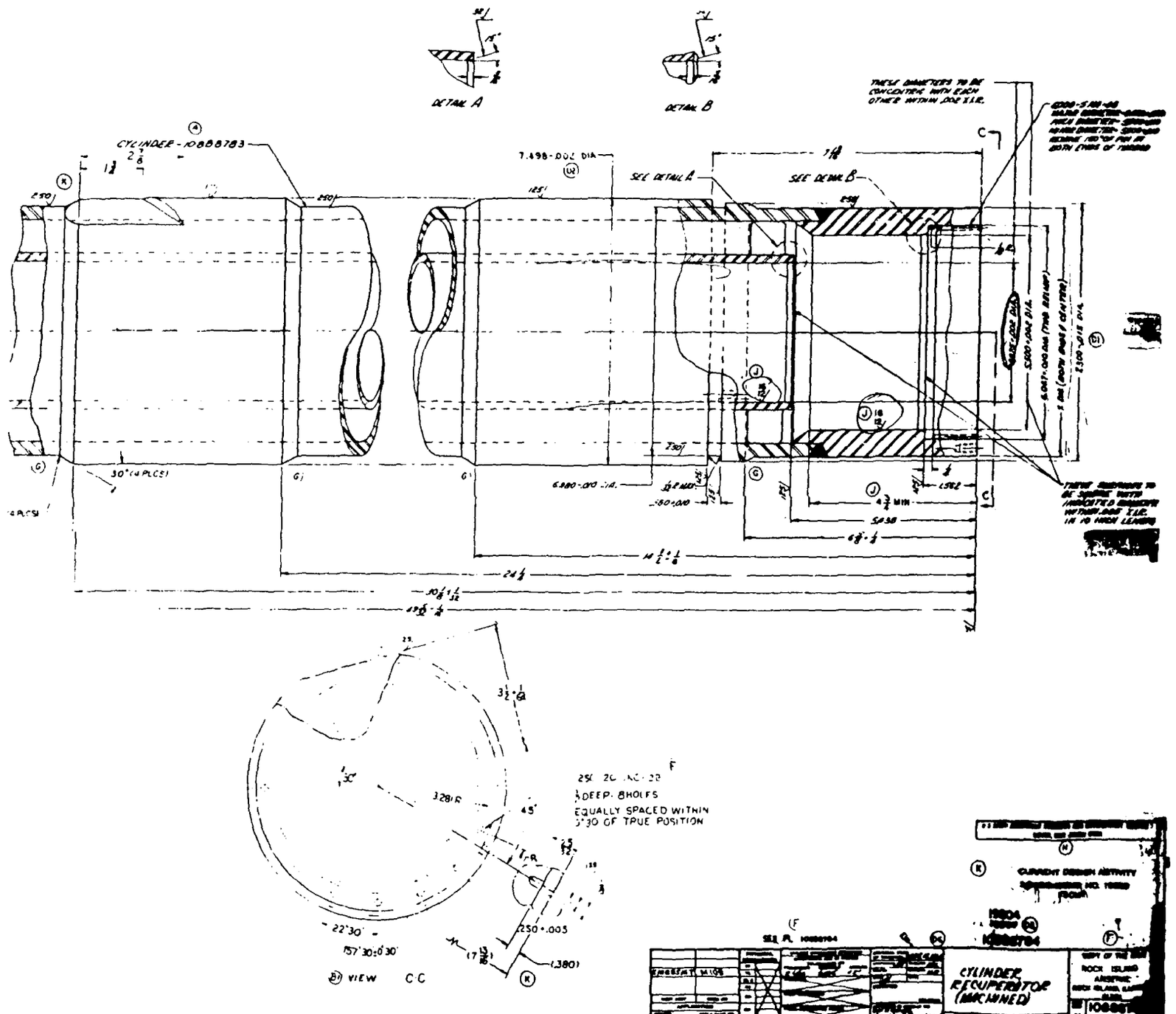
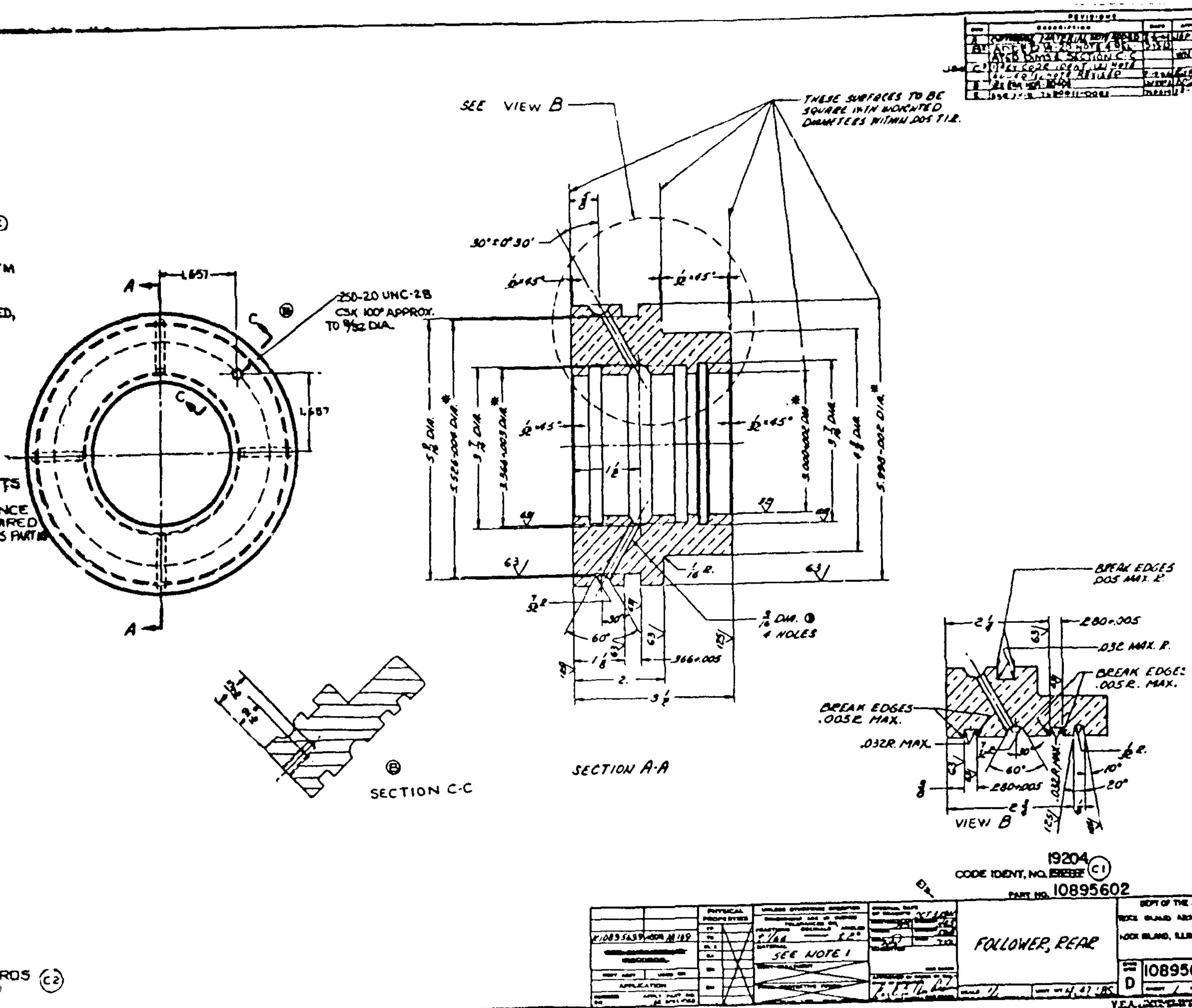
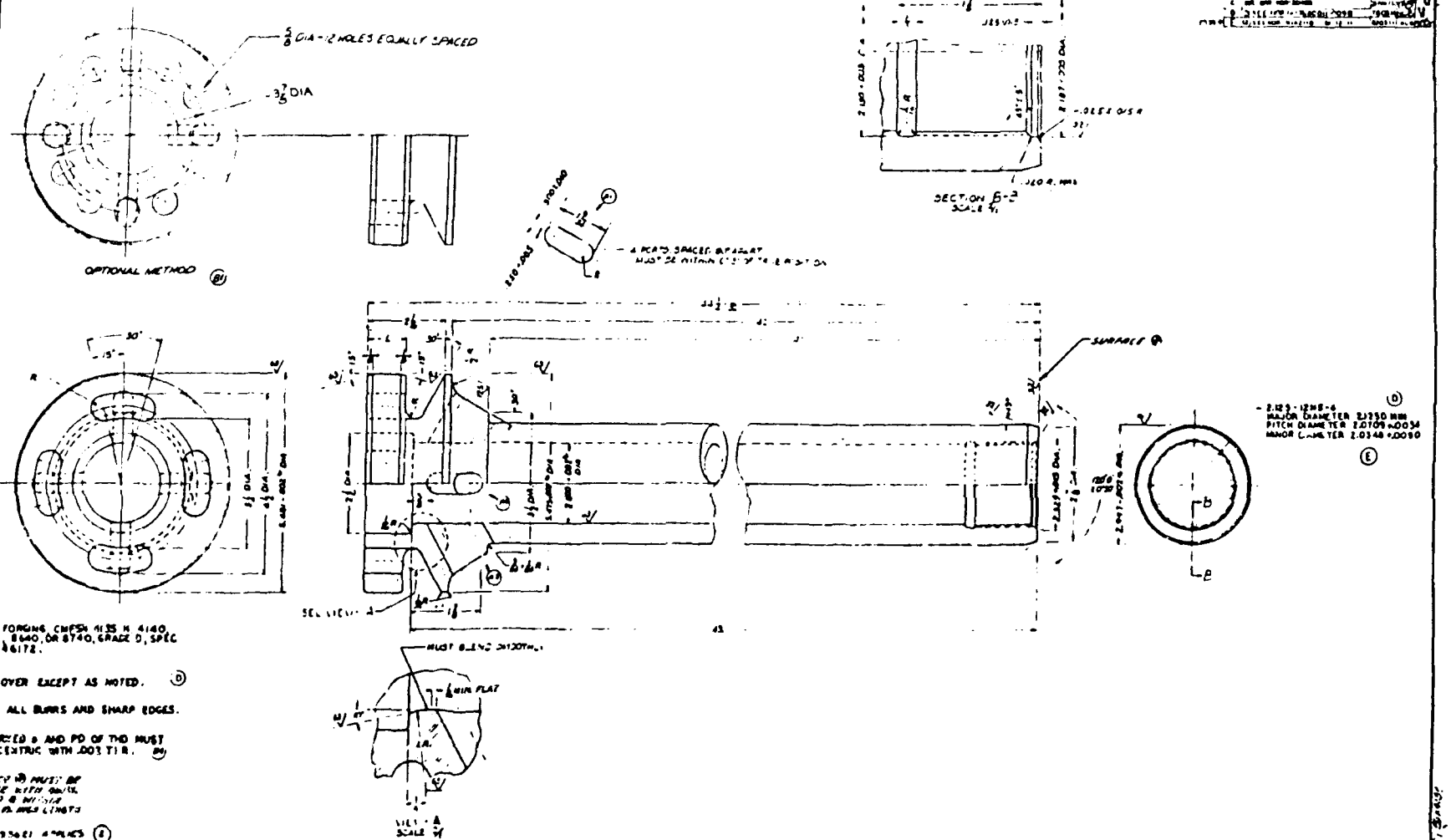

DETAIL A
DETAIL B
CYLINDER - 10888783
SEE DETAIL A
SEE DETAIL B
7.498-.002 DIA
6.980-.010 DIA.
30° (4 PLCS)
VIEW CC
CYLINDER RECUPERATOR (MACHINED)
ROCK ISLAND

NOTES:

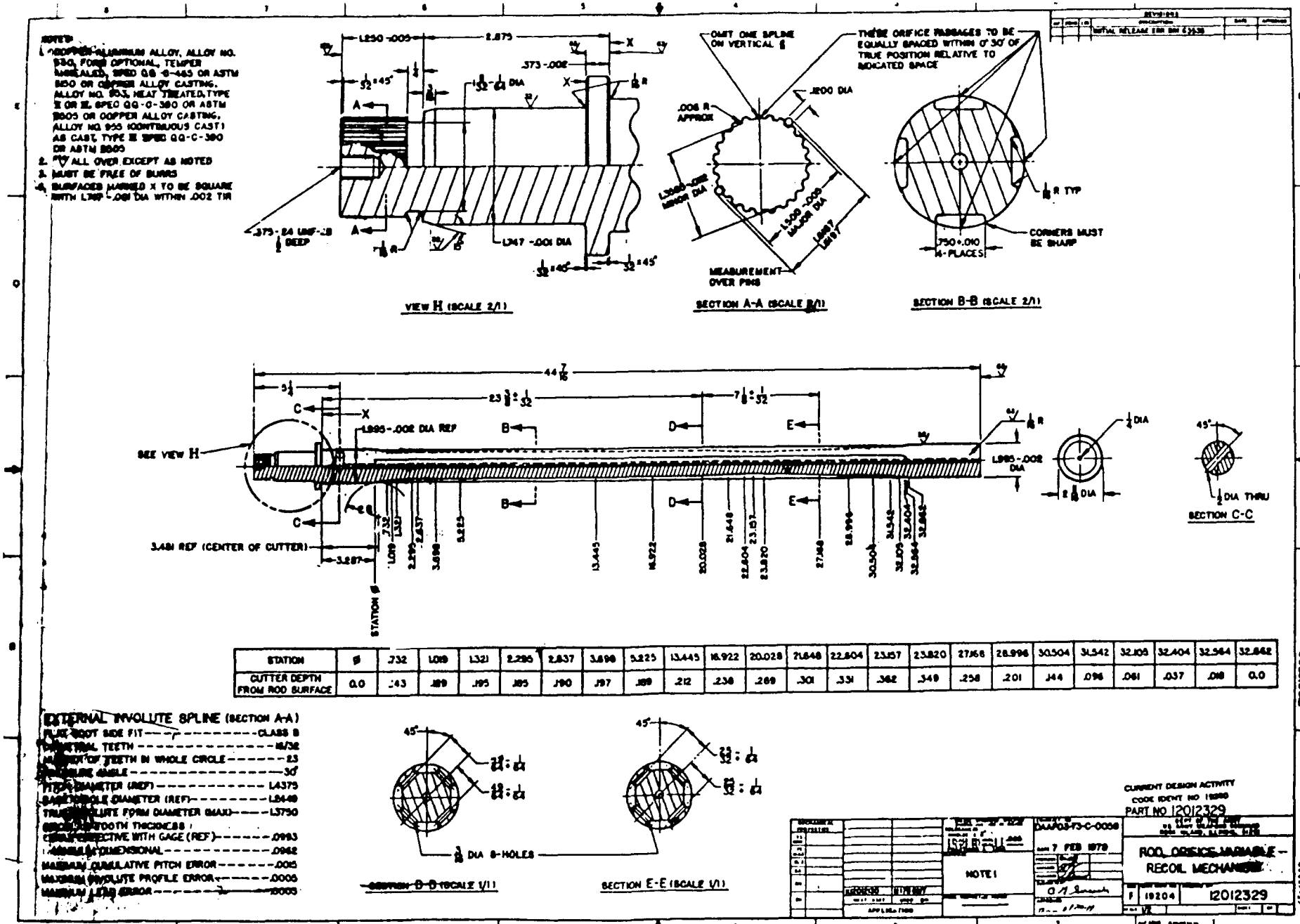
1. COPPER ALLOY CASTING, ALLOY NO. 955, TYPE II OR III - AS CAST, SPEC QQ-C-390 OR ASTM B271 OR B505 OR COPPER ALUMINUM ALLOY, ALLOY NO. 630, FORM OPTIONAL-ANNEALED, SPEC QQ-C-465 OR ASTM B150.
2. ALL OVER EXCEPT AS NOTED.
3. HOLES MARKED Ⓑ TO BE THOROUGHLY FREE OF FOREIGN MATTER & LOOSE PARTICLES.
4. DIAMETERS MARKED * TO BE CONCENTRIC WITHIN .002.
5. MUST BE FREE OF BURRS.
6. APPLY PART NUMBER PER MIL-STD-130.
7. IN ADDITION TO REQUIREMENTS OF THIS DRAWING, SUPPLEMENTARY QUALITY ASSURANCE PROVISIONS (SQAP) ARE REQUIRED FOR THIS ITEM. (SQAP NO. SAME AS PART NO.)



INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-STD-100


5/8 DIA - 2 HOLES EQUALLY SPACED
3 7/8 DIA
OPTIONAL METHOD
SECTION B-B
SCALE 4/1
SURFACE A
SECTION A-A
SCALE 4/1
NOTES:
1. STEEL FORGING, CMPSN 4135 H 4140, 8633 H, 8640, OR 8740, GRADE D, SPEC MIL-S-46172.
2. ALL OVER EXCEPT AS NOTED.
3. REMOVE ALL BURRS AND SHARP EDGES.
4. DIAS MARKED A AND PD OF THD MUST BE CONCENTRIC WITH .001 T.I.R.
5. SURFACES (B) MUST BE SQUARE WITH DIA'S MARKED A WITHIN .001 T.I.R. OVER ITS AREA LIMITS
6. MAP 10695621 4 PLACES
CURRENT DESIGN ACTIVITY
CODE IDENT. NO. 18200
PART NO. 10895621
TUBE, PISTON
10895621
F

WIA2110

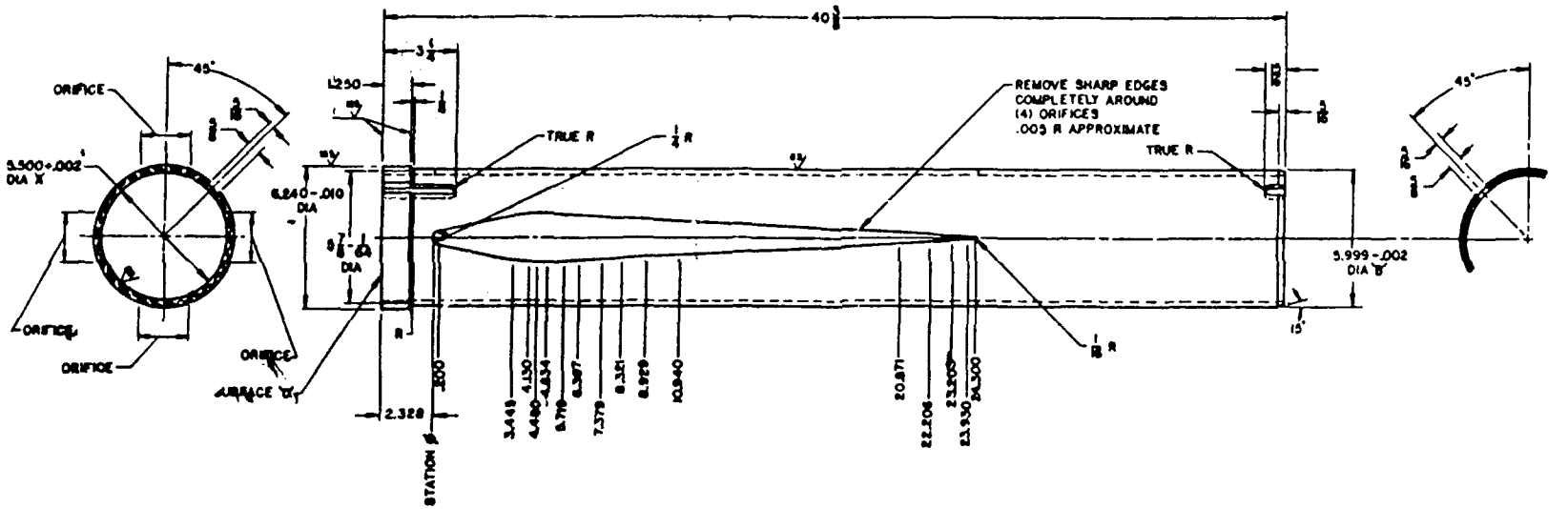


STATION	Ø	.732	1.089	1.321	2.295	2.837	3.698	5.225	13.445	16.922	20.028	21.648	22.804	23.157	23.820	27.168	28.996	30.504	31.542	32.105	32.404	32.564	32.662
CUTTER DEPTH FROM ROD SURFACE	0.0	.143	.189	.195	.185	.190	.197	.189	.212	.238	.269	.301	.331	.362	.349	.258	.201	.144	.096	.061	.037	.018	0.0

BRL-G3535

NOTES:

1. COPPER ALLOY CASTING, COPPER ALLOY NO. 955, TYPE II OR III AS CAST, SPEC QQ-C 390 OR ASTM B271 OR B505 OR COPPER ALUMINUM ALLOY, COPPER ALLOY NO. 630, FORM OPTIONAL, ANNEALED, SPEC QQ-C-465 OR ASTM B150
2. $\frac{125}{}$ ALL OVER EXCEPT AS NOTED
3. MUST BE FREE OF BURRS
4. EXACT SYMMETRY OF ORIFICES ABOUT CENTER LINES IS NOT REQUIRED
5. DIAMETERS 'A' AND 'B' MUST BE CONCENTRIC WITH EACH OTHER WITHIN .005 TIR AND SQUARE WITH SURFACE 'C' WITHIN .005 TIR



STATION	.200	3.445	4.130	4.480	4.834	5.718	6.397	7.379	8.321	8.929	10.940	20.871	22.206	23.203	23.930	24.300
FULL WIDTH OF ORIFICE	.629	1.963	2.146	2.199	2.200	2.072	1.997	1.840	1.737	1.656	1.447	.529	.377	.244	.125	.125

CURRENT DESIGN ACTIVITY
CODE IDENT. NO. 18203
PART NO 12012324

DAAF03-73-C-0059

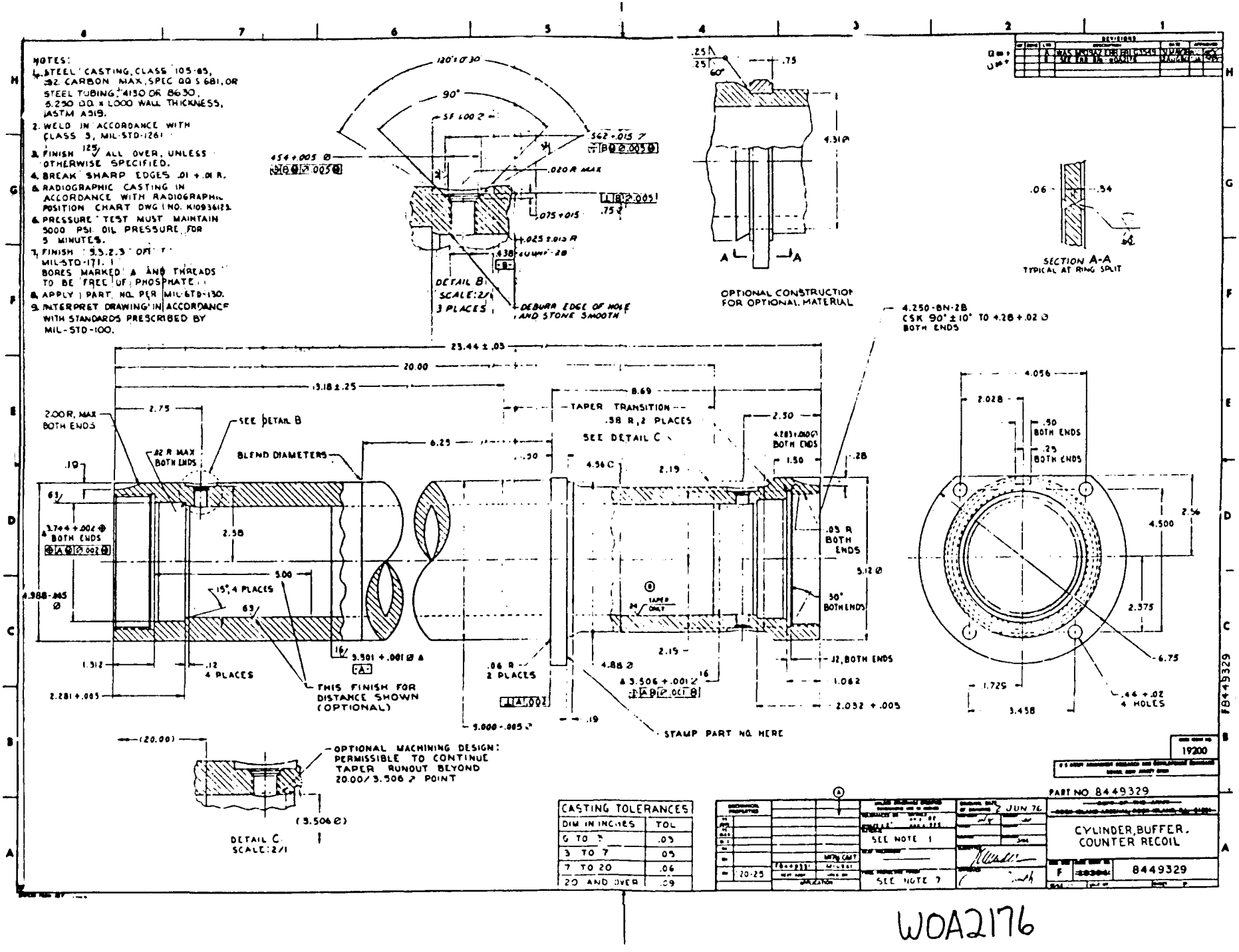
DATE 7 FEB 1978

NOTE 1

ORIFICE, OUTER, VARIABLE RECOIL

F | 19204 | 12012324

BRT-G3535


NOTES:
1. STEEL CASTING, CLASS 105-85, .32 CARBON MAX, SPEC QQ S 681, OR STEEL TUBING, 4130 OR 8630, 5.250 OD x 1.000 WALL THICKNESS, JASTM A519.
2. WELD IN ACCORDANCE WITH CLASS 3, MIL-STD-1261
3. FINISH 125 ALL OVER, UNLESS OTHERWISE SPECIFIED.
4. BREAK SHARP EDGES .01 + .01 R.
5. RADIOGRAPHIC CASTING IN ACCORDANCE WITH RADIOGRAPHIC POSITION CHART DWG I NO. K10936123.
6. PRESSURE TEST MUST MAINTAIN 5000 PSI OIL PRESSURE FOR 5 MINUTES.
7. FINISH 9.3.2.3 OF MIL-STD-171. BORES MARKED A AND THREADS TO BE FREE OF PHOSPHATE.
8. APPLY 1 PART NO. PER MIL-STD-130.
9. INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-STD-100.
DETAIL B SCALE: 2/1 3 PLACES
DEBURR EDGE OF HOLE AND STONE SMOOTH
OPTIONAL CONSTRUCTION FOR OPTIONAL MATERIAL
SECTION A-A TYPICAL AT RING SPLIT
23.44 ± .03
20.00
3.18 ± .25
8.69
TAPER TRANSITION .98 R, 2 PLACES
SEE DETAIL B
SEE DETAIL C
BLEND DIAMETERS
2.00 R, MAX BOTH ENDS
.32 R MAX BOTH ENDS
4.250-8N-2B CSK 90° ± 10° TO 4.28 + .02 Ø BOTH ENDS
4.283 +.000 BOTH ENDS
.03 R BOTH ENDS
30° BOTH ENDS
.12, BOTH ENDS
.06 R 2 PLACES
THIS FINISH FOR DISTANCE SHOWN (OPTIONAL)
STAMP PART NO. HERE
OPTIONAL MACHINING DESIGN: PERMISSIBLE TO CONTINUE TAPER RUNOUT BEYOND 20.00/3.506 ∅ POINT
DETAIL C SCALE: 2/1
.44 +.02 4 HOLES
CASTING TOLERANCES
DIM IN INCHES | TOL
0 TO 3 | .03
3 TO 7 | .05
7 TO 20 | .06
20 AND OVER | .09
SEE NOTE 1
SEE NOTE 7
JUN 76
PART NO 8449329
CYLINDER, BUFFER, COUNTER RECOIL
8449329
19200
A-8
8449329

WOA2176

APPENDIX B

LEVEL 300 CLEANLINESS CRITERIA

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CLASSIFICATION OF PRODUCT CLEANLINESS LEVELS

Table Ia

Derivation of Cleanliness Levels

Cleanliness Level	Range Surface and Fluids	Quantity of Particulates
10	5	Less than 3
25	5	21
	15	Less than 4
	25	1
50	5	180
	15	25
	25	7
	50	1
100	15	280
	25	75
	50	11
	100	1
200	15	4100
	25	1100
	50	180
	100	16
300	25	7000
	50	1000
	100	90
	250	Less than 3
500	50	11000
	100	950
	250	25
	500	1
750	100	6500
	250	170
	500	7
	750	1
1000	250	1000
	500	45
	750	7
	1000	1

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APPENDIX C

RIA M178 CLEANLINESS CRITERIA

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CURRENT M178 CLEANLINESS CRITERIA

TYPE OF PARTICLE	MAXIMUM SIZE IN MICRONS	NUMBER OF PARTICLES ALLOWED
1. FERROUS	40 TO 200	2
	>200	0
2. NONFERROUS	200 TO 400	2
	>400	0
3. ABRASIVE	200 TO 400	2
	>400	0
4. NONABRASIVE	NO REQUIREMENT	
5. LINT/FIBER	>3000 X 200 (WIDTH)	0
	>600 X 60 (WIDTH)	8

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APPENDIX D

SPECIFICATIONS FOR POWER SPRAY WASHER

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4. BASIC REQUIREMENTS

4.1 GENERAL

4.1.1 The power spray washer shall be capable of cleaning all M178 recoil components described in the enclosed drawings. All parts shall be power cleaned (washed and rinsed) in hot (80-180 degrees F.) aqueous solution with biodegradable detergent for the washing operations and hot (80-180 degrees F.) water with rust inhibitor for the rinsing operations. Both wash and rinse solutions shall be of composition and concentration such that they can be drained into a sanitary or municipal sewer at least once a day without further flushing or dilution. Each spray orifice shall deliver a minimum 5 gallons per minute (GPM) under a minimum pressure of 50 pounds per square inch (psi) for all cleaning operations.

4.1.2 The construction of the metal interior spray cabinet components, which includes spray yoke piping (SYP), spray orifices, baskets, turntable and fixtures (which secure cylinders in vertical position); metal components interior to the wash solution and rinse water tanks; and all metals exposed to cleaning solutions shall be from among the following stainless steel grades: 304; 304L; 304H; TP304H; 305; 308; 310; 316, 316L; 317; or 321. The interior cabinet walls shall be a minimum no. 8 gauge thickness.

4.1.3 The minimum inside working dimensions of the wash cabinet shall be 48 inches in diameter and 60 inches in vertical height. The height shall be measured from the bottom of the turntable to the point where the top spray orifices are positioned for cleaning. The top of the turntable shall be a maximum of 24 inches above the floor level. The wash solution tank shall be located directly below the turntable on the power spray cabinet.

4.1.4 The cabinet shall be capable of simultaneously cleaning four piston tubes, four inner orifices, and four outer orifices or of simultaneously cleaning two recoil buffer cylinders and two recuperator cylinders. A leak proof door in the power spray cabinet shall be designed to open from vertical hinges strong enough to support the door without causing distortion, buckling, or failure. The width of the cabinet door shall be such that when fully opened, half the turntable shall be exposed from the side and from above. That is to say the width of the door shall be equal to the outside diameter of the cabinet if it is circular or the maximum distance between any two wall intersections if the cabinet has another geometry. The height of the cabinet door shall be at least 60 inches (minimum vertical height working distance). The washer shall allow access to load components from suspended hydraulic hoists into the spray cabinet via the side. The turntable shall be able to be rotate and locked into position providing ease of access during loading and unloading.

4.1.5 At least one removable basket shall be provided for cleaning small components with a maximum capacity of 200 pounds of components being cleaned per basket. The basket(s) shall be rotated by a friction driven turntable. The spray orifices shall be directed at the components in the baskets from the sides and top (as a minimum). The spray orifices on horizontal SYP shall be 16 to 24 inches above the bottom of the basket. The basket(s) shall be of mesh construction so water can readily pass through. Handles shall be located every 90 degrees on the basket(s) to help operators with loading.

4.1.6 The components in 4.1.4 shall sit on a turntable. The minimum load capacity for the turntable shall be 1000 pounds. Support fixtures shall be designed to hold the cylinders in a vertical position during the cleaning. The support fixtures shall be designed in such a way as not to enter the inside of the cylinders. The support fixtures for the components listed in 4.1.4 shall be affixed to the turntable. During washing and rinsing, the turntable with affixed support fixtures shall rotate by a friction drive at a rate of two to four revolutions per minute (rpm). If there are two different sets of support fixtures, (one set for buffer and recuperator cylinders and one set for the remaining cylinders), then they shall be interchangeable within 5 minutes. The support fixtures shall be coated with applicable material to ensure that the components to be cleaned are not scratched during the loading, unloading and cleaning operations. This protective coating shall withstand alkaline detergents and rust inhibitors at temperatures of 180 deg. F. on a continual basis.

4.1.7 SYP which shall contain spray orifices to provide wash and rinse solutions to the components, shall have a minimum inside diameter of 5/8 inch. SYP shall run the vertical height of the inside working dimension of the spray cabinet. Horizontal SYP shall provide orifices as necessary to clean components in this statement of work, including at least one orifice of which is in a vertical line with the center of the turntable. All spray orifices shall be easily removable from the SYP to allow cleaning of the spray orifices.

4.1.8 Because of the different configurations of the components shown in the enclosed drawings, each component shall have specifically designed spray orifices oriented to ensure that the surfaces are cleaning (washed and rinsed) per 300 level cleanliness requirements of MIL-STD-1246B and rinsing requirements of paragraph 4.3.5. In cleaning (washing and rinsing) the exterior surfaces of the cylinders, there shall be a minimum of six spray orifices located on horizontal SYP. There shall be a minimum of ten spray orifices located on vertical SYP. In cleaning (washing and rinsing) the interior surfaces of the cylinders, there shall be a minimum of one spray orifice for each cylinder, that will deliver a spray of wash solution and rinse water up the inside diameter of the cylinders.

4.1.9 The wash solution tank shall be a minimum 100 gallons capacity.

4.1.10 There shall be a minimum 18 kw electric heat source for each of the wash solution and rinse solution tanks. The wash solution tank and rinse water tank shall be capable of being heated to 180 deg. F. within 1 hour. The temperature for each of the wash and rinse solutions shall be adjustable (set) by the operator in increments of 10 deg. F. The actual temperatures at the start of the wash or rinse cycle shall be within $\pm$5 deg. F. of the temperature setting for the wash tank or rinse tank, respectively. There shall be 24-hour minimum 7-day timers that will automatically turn the heaters on and off.

4.1.11 In each of the wash solution and rinse water tanks, there shall be either an automatic water level control and/or other damage protective devices sufficient to protect the heating elements from air exposure while hot. These shall automatically shut off the power to the appropriate heater and set off both an audible and visual signal.

4.1.12 The door to the exterior of the power spray washer shall be designed to prevent water and steam from escaping the cabinet.

4.2 CLEANING OPERATION REQUIREMENTS

4.2.1 The cleaning operation shall consist of a separate wash and rinse operation. All operations shall be able to be integrated with one another (continual operation with no operator intervention once the initial wash operation begins). During the wash operations, the interior and exterior surface of all cylinders must be spray washed. The wash operations must be completed before the rinse operation initiates. The wash and rinse operations shall clean all surfaces as the turntable rotates at a rate of 2-4 rpm. The washer shall allow cleaning of smaller components per 4.1.5.

4.2.2 Once the washer is loaded and the solutions are heated to the selected temperatures, the entire cleaning operation shall not need to exceed 30 minutes after the washer is started. Cycle times for the wash and rinse shall be operator adjustable with 1-minute increments up to a total of 30 minutes each.

4.2.3 The power spray washer shall be able to be manually shut off at any time during the cleaning cycle.

4.2.4 There shall be a separate 150 gallon minimum rinse water tank that is to be heated per 4.1.10. The rinse tank shall have a hinged top that will prevent water and steam from escaping the tank. The washer shall include all connections and fittings including electrical and piping from the rinse tank to operate with the washer. During the rinsing operation, the power spray washer shall have the capacity to pump the rinse water from the rinse water holding tank to the power spray washer cabinet via the filtration system and back to the rinse water holding tank. The rinsing operation shall begin only after the washing cycle is complete. The rinse water shall not mix or empty into the wash solution tank located below the power spray cabinet turntable. Likewise, the wash solution shall not mix or empty into the rinse water tank.

4.2.5 The aqueous wash solution and rinse with rust inhibitor shall each be filtered through a different set of three separate filter cartridges. The last filter cartridge in each set shall consist of a 5 micron retention filter. The filter cartridges shall be inline and shall be capable of being replaced (when dirty) within 5 minutes.

4.2.6 During the washing operation, the wash solution and rinse water shall circulate from the wash tank and rinse tank, respectively, through the appropriate filter system to the power spray cabinet. If the settings for the wash and rinse operations require greater volumes of solutions than are contained in the respective tanks before cleaning commences, the solutions shall recycle continuously through the appropriate tanks back to the washing cabinet during operation.

4.2.7 There shall be both an audible and visual light signal when the cleaning operation is complete.

4.2.8 Both wash and rinse tanks shall have side drains that completely drain the tanks within 15 minutes. The bottoms of the tanks shall be sloped as to provide complete drainage. Each drain shall have a valve for manual opening and closing and shall be equipped with standard fittings for leak proof connections to standard flexible tubing. The only manual operation for draining the tanks shall be to open or close the valves. Two 12-foot lengths of flexible tubing that fit the connections shall be provided.

4.3 DEIONIZER UNIT

A deionizer unit shall be provided to refill (recharge) the wash and rinse tank with water as required. The minimum output of the deionizer unit shall be 100 gallons per hour. The deionizer unit shall be a cartridge type that contains mixed ion exchange resin. There shall be a minimum of two such cartridges. The only maintenance that will be required of the deionizer unit is the replacing of cartridge(s) when dirty. There shall be an in-line resistivity meter to indicate water quality, with at least two scales, one between .1 and 1 mego hms and another between 1 and 10 mego hms. There shall be a light sensor indicating when the cartridge needs to be changed. The water quality of the deionizer unit shall meet the American Society for Testing and Materials, type IV water as specified below.

1.	Total organic matter, mg/L	2.0
2.	Electrical conductivity, maximum micro-mho/cm at 25 deg. C.	5.0
3.	Electrical sensitivity, minimum mego hms at 25 deg. C.	0.2
4.	Maximum soluble silica	No limit
5.	Microbiological classification	No limit
6.	pH at 25 deg. C.	5-8
7.	Hardness $CaCO_3$ mg/l	1-3

All fittings and tubing shall be provided from the deionizer unit to the wash and rinse tanks. These shall be of standard sizes. Leakproof manually closable valves shall be provided at the wash and rinse tanks. There shall be a visual and audible indicator for each tank to alert the operator when the tank is full.

APPENDIX E

TEST REPORT - ACCEPTANCE TEST FOR FIRST ARTICLE WASHER

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BETTER ENGINEERING LEVEL 300 TEST RESULTS

First Wash Cycle

Part Number	Noun	Pass (P)/Fail (F)
192004	Buffer Cylinder	P
329	Buffer Cylinder	P
8-169	Outer Orifice	F
8-53	Outer Orifice	F
9217	Inner Orifice	P
9184	Inner Orifice	P
978	Piston Tube	P
866	Piston Tube	P

Second Wash Cycle

Part Number	Noun	P/F Level 300
921	Buffer Cylinder	P
924	Buffer Cylinder	P
4485	Outer Orifice	P
4502	Outer Orifice	P
9257	Inner Orifice	F
9186	Inner Orifice	F
8-122	Piston Tube	F
990	Piston Tube	F

Third Wash Cycle

Part Number	Noun	P/F Level 300
910	Buffer Cylinder	P
909	Buffer Cylinder	P
9248	Inner Orifice	P
9237	Inner Orifice	P
9101	Piston Tube	P
9323	Piston Tube	F
9-151	Recuperator Cylinder	P
9-132	Recuperator Cylinder	P

Fourth Wash Cycle

Part Number	Noun	P/F Level 300
921	Buffer Cylinder	P
9-188	Outer Orifice	P
9-289	Inner Orifice	P
9198	Recuperator Cylinder	F
8098	Piston Tube	P

Fifth Wash Cycle

Part Number	Noun	P/F Level 300
9317	Outer Orifice	F
9204	Outer Orifice	P

Sixth Wash Cycle

Part Number	Noun	P/F Level 300
9098	Recuperator Cylinder	F
9101	Recuperator Cylinder	P

7 sets of parts were cleaned except for recuperator cylinders of which 5 each were cleaned.

23 of 33 passed level 300 = 70%

APPENDIX F

TEST REPORT FOR FINAL ACCEPTANCE TEST

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ROCK ISLAND ARSENAL

REQUEST FOR TEST AND LABORATORY RESULTS

LAB. NUMBER	DATE RECEIVED	PURCHASE ORDER NUMBER	ITEM NUMBER	DATE
90-4271	25 Oct 90			25 Oct 90

QA NUMBER	EX ORDER NUMBER	REQN NUMBER	CHARGE TO
			003821-1210000

CHECK APPLICABLE BLOCK:

[XX] PARTICULATE CONTAMINATION [ ] CHEMICAL ANALYSIS [ ] FAILURE ANALYSIS [ ] OTHER

MATERIAL:

Acceptance test (level 300) results of Better Engineering Power Spray Washer.
Contract DAAA08-89-C-0083

SIZE	QTY	SPEC NUMBER	REC'D FROM	INSP/PHONE
1 pt	32			

COMMENT: Thirty-two components were tested per acceptance test of subject contract. Ninety percent of the components (28) must meet the level 300 test requirements for the power washer to be accepted. Much fewer particles were found on the components than allowed per level 300 requirements. All components were vapor degreased then polished prior to power spray washing with an exception of four piston tubes which had honing oil on them. Test results show that 28 of the 32 components passed the level 300 test.

THOMAS G. CIZICKI
SMCRI-SEM-E

26 OCT 1990

LABORATORY RECOMMENDATION:

[XX] Accept [ ] Reject [ ] For Information Only

DARYOUSH V. ASSADI
(SIGNATURE)

SMCRI FORM 57-1, 1 FEB 88 REPLACES EDITION OF 1 NOV 83, WHICH WILL BE USED

PARTICLE TYPE (SIZE IN MICRONS)

PART NO.	FERROUS	NONFERROUS	ABRASIVE	NONABRASIVE	P/F
Detrix rinse Tank control	-	10 x 50	-	-	P
1. Piston tube #0009	-	225 x 25 300 x 100	-	200 x 150 150 x 100-4	P
2. Piston tube #8145	250 x 25	-	150 x 150	250 x 150	P
3. Piston tube #8137/W/ honing oil	150 x 100 150 x 50	50 x 50 150 x 25-2	-	50 x 50-5 100 x 50-2 150 x 50-4 175 x 100 150 x 100	P
4. Piston tube #9908 w/ honing oil	-	150 x 17	-	150 x 100-2 400 x 200	P
5. Piston tube #9901 w/ honing oil	200 x 25 100 x 25	100 x 50 100 x 25	100 x 50 100 x 25	150 x 50-3 150 x 150-2 150 x 100	P
6. Piston tube #674 w/ honing oil	250 x 75 200 x 25	150 x 25 100 x 100	225 x 100 150 x 50	100 x 100 200 x 100 100 x 50	P
7. Inner orifice #9177	200 x 50 150 x 25-3	200 x 25 200 x 50 150 x 25-3 150 x 100 100 x 50	225 x 100	450 x 250-2 850 x 250	P
8. Inrer orifice #0012	-	150 x 100	200 x 100 100 x 50	200 x 100-3 150 x 150-2 100 x 100-9	P
9. Inner orifice #9228	250 x 25	350 x 150 250 x 100 100 x 50	250 x 150 225 x 225 225 x 175 200 x 200	150 x 100 450 x 250 250 x 50 450 x 150 250 x 250 350 x 150 350 x 100 200 x 200-2 850 x 400	F

PART NO.	FERROUS	NONFERROUS	ABRASIVE	NONABRASIVE	P/F
10. Inner orifice #9231	200 x 50 100 x 25 150 x 50 225 x 50	-	225 x 100	300x 100	P
11. Inner orifice	-	300 x 100	100 x 50 150 x 150 250 x 200	150 x 100-5	P
12. Inner orifice #9250	400 x 175 300 x 50 225 x 50 100 x 75 200 x 25	50 x 50-5 125 x 125-2 200 x 150-2 600 x 600 350 x 17	250 x 250	2,500 x 750 2.500 x 1000	F
13. Inner orifice #0026	-	225 x 50	150 x 100	150 x 100-2 150 x 50-2 1000x 500	P
14. Buffer #201	350 x 25 150 x 25 150 x 100 100 x 50 100 x 100	150 x 100 100 x 100 150 x 50 175 x 100	-	150 x 100	P
15. Buffer #0198	-	-	150 x 50	150 x 100-4 100 x 50-5	P
16. Bufffer #0199	-	400 x 275 200 x 50 150 x25-2	500 x 250 100 x 100	150 x 100	P
17. Buffer #200	100 x 50	150 x 25	250 x 150 225 x 100 150 x 100	150 x 50 100 x 100 150 x 100-3	P
18. Outer orifice #0188	400 x 50 350 x 25 200 x 17 200 x 50 100 x 50-5	350 x 50 275 x 25 225 x 50-2 200 x 17	350 x 200 100 x 100-3	-	F
19. Outer orifice #0059	150 x 100 150 x 50	- (Clear)	100 x 50 500 x 4	200 x 150-5	P
20. Outer orifice #0005	350 x 17 150 x 25 150 x 100	300 x 50 250 x 100 150 x 25	400 x 200	225 x 50	F

PART NO.		FERROUS	NONFERROUS	ABRASIVE	NONABRASIVE	P/F
21.	Outer orifice #0143	-	350 x 250 150 x 25 100 x 25	150 x 150 200 x 150	350x 250 (Yellow)	P
22.	Outer orifice #9123	250 x 50 150 x 100	225 x 25	325 x 150 100 X 25	225 x 150 (Grease splotches)	P
23.	Outer orifice	-	125 x 50 100 x 50	(Yellow)	238 x 150-3 250 x 200 300 x 150	P
24.	Recuperator #0047	200 x 100 400 x 150	-	200 x 150 150 x 100-5 100 x 100		P
25.	Recuperator #0081	240 x 50 200 x 100 300 x 150	-	150 x 100	100 x 100-20	P
26.	Recuperator #0022	400 x 17 225 x 25 250 x 150 200 x 150	-	225 x 175 150 x 100	-	P
27.	Recuperator #0073	350 x 350 100 x 50	150 x 25 100 x 25	-	150 x 100 200 x 150	P
28.	Recuperator #5316	400 x 400 100 x 100 150 x 100-2	200 x 150	200 x 150 (Red) 150 x 150 15 x 5 (Glass)	150 x 100-5	P
29.	Recuperator #0032	375 x 25 150 x 100	200 x 25 150 x 100 -2	150 x 100-2 225 x 150	150 x 100-3	P
30.	Piston tube #044	250 x 50 200 x 50	-	200 x 150	150 x 100	P
31.	Inner Orifice #0024	-	200 x 25 150 x 150 175 x 25	250 x 400 (Red) 100 x 150-2 300 x 100	150 x 100-3	P
32.	Inner orifice #0022	150 x 50	150 x 25 50 x150-2 100 x 100	225 x 200 150 x 100	200 x 150-5	P

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INDUSTRIAL POWER SPRAY WASHER
Thomas G. Gizicki, Rock Island Arsenal

Report SE-92-01, 44 p. incl. illus. tables,
(AMS Code 3297.06.8248) Unclassified Report.

The method of cleaning M178 recoil components prior to final assembly has varied over the past 25 years. Introduction of new cleaning methods and chemicals over this period has caused a small improvement on how well these components were cleaned. Therefore, a more effective method for cleaning the components needed to be developed. An aqueous power spray washer was designed to clean all M178 gun mount components, except for the M178 cradle assembly. Benefits realized from this unit include better cleaning, greater productivity, absence of a hand washing operation and elimination in the use of hazardous solvents.

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